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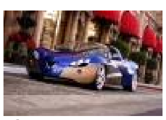

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Nanotech promises the first viable alternative to batteries in 200 years

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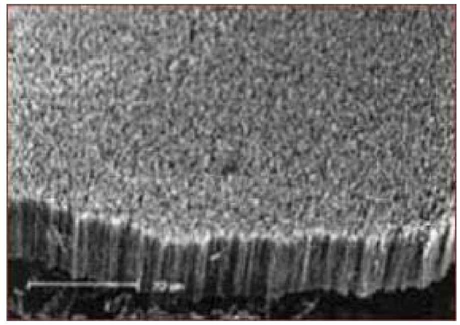

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February 14, 2006 Almost everything we use requires electrical storage via a battery - computers, cell phones, cars, personal entertainment devices and much more – and as compelling functionality has increased in the digital age, so too has our reliance on the traditional battery which has changed little since it was developed by Alessandro Volta in 1800. Now, work at MIT's Laboratory for Electromagnetic and Electronic Systems (LEES) holds the promise of the first technologically significant and economically viable alternative to conventional batteries in more than 200 years. Using nanotube structures, the LEES invention promises a significant increase on the storage capacity of existing commercial ultracapacitors by storing electrical fields at an atomic level. The new LEES ultracapacitors could replace the conventional battery in everything from the smallest MP3 players through to electric automobiles and beyond, yielding batteries with a lifetime equivalent to the product they power and recharging times inside a minute. Most significantly, they promise a much smaller and lighter "battery", and will be an enabling technology for many new concepts such as electric bicycles with the "burst" peak power of a motorcycle, or electrical trams with the capacity of a train but without the infrastructure. In automotive terms, they raise the possibility of an integrated starter/generator and the capability of ultra-efficient regenerative braking systems. The work was presented at the recent 15th International Seminar on Double Layer Capacitors and Hybrid Energy Storage Devices and the LEES "batteries" could reach market within five years. A potentially disruptive technology!

The word "battery" was first used by Benjamin Franklin in 1748 to describe an array of charged glass plates. In 1800, Alessandro Volta of Italy built the voltaic pile and discovered the first practical method of generating electricity. Constructed of alternating discs of zinc and copper, with pieces of cardboard soaked in brine between the metals, the voltic pile produced electrical current. The metallic conducting arc was used to carry the electricity over a greater distance. Volta's voltaic pile was the first "wet cell battery" that produced a

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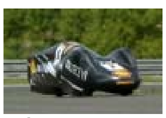

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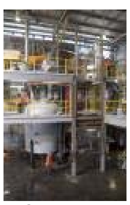

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reliable, steady current of electricity.

The fuel cell was developed by William Robert Grove in 1839, the first practical storage lead-acid battery that could be recharged followed in 1859 (and is still in use today in most automobiles) and the first commercially successful dry cell battery (zinc-carbon cell) followed in 1881 with the nickel cadmium battery in 1899. Thomas Edison invented the alkaline storage battery in 1901 and for the last century, improvements in battery technology have been incremental rather than revolutionary.

Now, with the advent of the digital age, battery technology has been one of the crucial limiting factors. Joel E. Schindall, the Bernard Gordon Professor of Electrical Engineering and Computer Science (EECS) and associate director of the Laboratory for Electromagnetic and Electronic Systems; John G. Kassakian, EECS professor and director of LEES; and Ph.D. candidate Riccardo Signorelli are using nanotube structures to improve on an energy storage device called an ultracapacitor.

Capacitors store energy as an electrical field, making them more efficient than standard batteries, which get their energy from chemical reactions. Ultracapacitors are capacitor-based storage cells that provide quick, massive bursts of instant energy. They are sometimes used in fuel-cell vehicles to provide an extra burst for accelerating into traffic and climbing hills. However, ultracapacitors need to be much larger than batteries to hold the same charge.

The LEES invention would increase the storage capacity of existing commercial ultracapacitors by storing electrical fields at the atomic level.

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Page: 1 2

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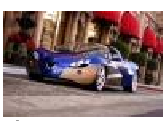
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Although ultracapacitors have been around since the 1960s, they are relatively expensive and only recently began being manufactured in sufficient quantities to become cost-competitive. Today you can find ultracapacitors in a range of electronic devices, from computers to cars.

However, despite their inherent advantages - a 10-year-plus lifetime, indifference to temperature change, high immunity to shock and vibration and high charging and discharging efficiency - physical constraints on electrode surface area and spacing have limited ultracapacitors to an energy storage capacity around 25 times less than a similarly sized lithium-ion battery.

The LEES ultracapacitor has the capacity to overcome this energy limitation by using vertically aligned, single-wall carbon nanotubes - one thirty-thousandth the diameter of a human hair and 100,000 times as long as they are wide. How does it work? Storage capacity in an ultracapacitor is proportional to the surface area of the electrodes.

Today's ultracapacitors use electrodes made of activated carbon, which is extremely porous and therefore has a very large surface area. However, the pores in the carbon are irregular in size and shape, which reduces efficiency. The vertically aligned nanotubes in the LEES ultracapacitor have a regular shape, and a size that is only several atomic diameters in width. The result is a significantly more effective surface area, which equates to significantly increased storage capacity.

The new nanotube-enhanced ultracapacitors could be made in any of the sizes currently available and be produced using conventional technology.

"This configuration has the potential to maintain and even improve the high performance characteristics of ultracapacitors while providing energy storage densities comparable to batteries," Schindall said. "Nanotube-enhanced ultracapacitors would combine the long life and high power characteristics of a commercial ultracapacitor with the higher energy storage density normally available only from a chemical battery."

This work was presented at the 15th International Seminar on Double Layer Capacitors and Hybrid Energy Storage Devices in Deerfield Beach, Fla., in December 2005.

The work has been funded in part by the MIT/Industry Consortium on Advanced Automotive Electrical/Electronic Components and Systems and in part by a grant from the Ford-MIT

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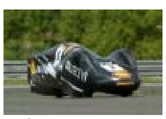

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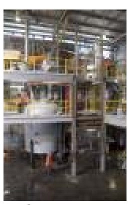

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